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Title: NICKEL-FREE COBALT ALLOY ;

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#### ABSTRACT:

A hard facing alloy is derived, which is devoid of nickel and which on application to a nickel based alloy member, is heated along with the member, in a manner which substantially prevents transfer of nickel from the member, to the hard facing alloy. The alloy consists of % wt  
Co 50-60 Cr 5-35 W 0-10 C 0-2.5 Si 0.10 B 0-3.5 with the remainder being impurities, and at least one of Si and/or B is present.

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(58) Field of search

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(54) Nickel-free cobalt alloy

(57) A hard facing alloy is derived, which is devoid of nickel and which on application to a nickel based alloy member, is heated along with the member, in a manner which substantially prevents transfer of nickel from the member, to the hard facing alloy.

The alloy consists of

	% wt
Co	50-60
Cr	5-35
W	0-10
C	0-2.5
Si	0-10.0
B	0-3.5

with the remainder being impurities, and at least one of Si and/or B is present.

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## SPECIFICATION

## Facing for metal and its application

- 5 This invention relates to hard facing alloys for nickel based alloy compounds and methods of application thereof. 5
- Nickel based alloys are widely used to make parts, which operate in conditions of high fretage with consequent wear. However, such alloys have poor resistance to wear by fretage; consequently they are coated with a thin layer of hard facing material, the anti-wear characteristics of which are more in keeping with the operating conditions. 10
- 10 Two such hard facing materials are Cobalt based alloys, sold under the Registered Trade Marks "STELLITE 12 SF" and "STELLITE 12".
- Those nickel alloy parts having layers of "STELLITE 12" or "STELLITE 12 SF" have indeed exhibited wear resistance in excess of that of the base alloy and have thus had their operating lives lengthened. However, inherent characteristics of the known hard facing alloys, has prevented the realisation of at least a substantial portion of the wear resistance potential available. 15
- 15 It is an object of this invention, to provide a Cobalt based, hard facing alloy which will realise a greater proportion of the wear resistance available, than has been achieved hitherto. Further, it is an object of this invention, to provide a method of applying the new alloy to a nickel based parent alloy, so as to realise said greater wear resistance potential during operation of a part made from the parent alloy. 20
- The present invention provides a nickel free hard facing alloy, consisting of the following constituents in the proportions stated, as a weight percentage: 25
- |  |  |    |
|--|--|----|
| Co   | 50-60%                                     |    |
| Cr   | 5-35%                                      |    |
| W  | 0-10%                                      |    |
| 30 C   | 0-2.5%                                     | 30 |
| Si   | 0-10% where if Si = 0, some B is present.  |    |
| B  | 0-3.5% where if B = 0, some Si is present. |    |
| Remainder impurities.  |  |    |
| Preferably the proportions comprise by weight:-  |  | 35 |
| 35 Co  | — 52%                                      |    |
| Cr   | — 31%                                      |    |
| W  | — 8%                                       |    |
| C  | — 1.4%                                     |    |
| 40 Si  | — 4.5%                                     | 40 |
| B  | — 2.9%                                     |    |
| Remainder impurities.  |  |    |
| The alloy is one which can be produced in powder form.   |  |    |
| Preferably the mesh size of the powder ranges from 45 to 105 microns.  |  |    |
| 45 The present invention further provides a method of applying the new hard facing alloy to a nickel based alloy member including the steps of forming a flexible tape by suspending the hard facing alloy in powder form in a polymeric binder and drying the binder by allowing vapourising off of its solvent content, laying the resulting tape on a surface of the nickel base alloy member and heating the resulting assembly in a vacuum, to a temperature 10 to 25°C above the liquidus of the hard facing alloy for 15 minutes. | 45   |    |
| 50 Preferably a previous heating of the assembly, is performed at substantially 500°C for 30 minutes to avoid violent volatilisation of the binder.  | 50   |    |
| The manufacture of a tape of the alloy of the invention, and the manner of its treatment to provide a hard surface layer on a nickel based alloy part, is described hereafter by way of example.   | 55   |    |
| 55 Four basic substances were first obtained, in powder form, by mixing of the constituents listed in table 1 in the proportions stated.   |  |    |

TABLE 1

Alloy	Nominal Composition of Hard Facing Powders								Particle Size	
	Co	Cr	W	C	Ni	Mo	Si	B		
A	59	29	9	1.8	—	—	—	—	— 250	+ 300
B	52	19	9	1.0	13	—	2.5	1.5	— 250	+ 300
C	52	31	8	1.4	—	—	4.5	2.9	— 140	+ 325
D	62	8	—	—	—	28	2.0	—	— 325	

It should be noted that in all tables, the hard facing alloys which are embraced by the present invention are designated 'C', A/C and C/D whereas the remaining alloys A, B and D are commercially available products.

The solidus and liquidus values for each of the alloys were determined as shown in Table 2.

TABLE 2

Alloy	Solidus	Liquidus
A	1280°C	1315°C
B	1065°C	1145°C
C	1065°C	1090°C
D	1230°C	1590°C

Table 2 clearly shows that alloy 'C' had, with alloy 'B', the lowest solidus value and the lowest liquidus value of all the alloys. This is directly attributable to the inclusion of Si and B.

Alloys were also made of A and C and C and D respectively, to see if any of the characteristics of alloy C could be introduced in such mixes.

Flexible tapes were made up as follows: Each powder was placed in a respective solution, comprising a suitable acrylic binder of the polymethyl methacrylate type. This choice of binder was made because it gave sufficient flexibility and further, left no residue, when pyrolysed in an inert atmosphere. Drying of the solution to actually form the tapes, was achieved by evaporation of solvent therefrom.

Portions were cut from each tape and placed on respective nickel alloy parts, being retained there by a pressure sensitive adhesive. Each assembly was then heated, first for half an hour at 500°C, to avoid too violent volatilisation of the binder, then for 15 minutes at temperatures which varied from 1100°C to 1190°C as shown in table 3 hereafter, in order to effect brazing of the surface layer to the parent body.

It should be understood that the letters "DNB" mean "did not braze".

TABLE 3

Alloy	Braze Temp °C	Result	Nom. Tape Thickness	Deposit Thickness	% Thickness Loss	Hardness (Parent Alloy = 383 VPN)
B	1075	DNB	—	—	—	—
	1100	DNB	—	—	—	—
	1125	DNB	—	—	—	—
	1150	BRAZED	0.82	0.61	25	513
C	1175	—	—	—	—	—
	1190	BRAZED	0.71	0.69	4	446
C	1075	DNB	—	—	—	—
	1100	BRAZED	0.74	0.43	42	746
	1125	BRAZED	—	—	—	658
	1150	BRAZED	0.74	0.38	51	552
	1175	BRAZED	0.79	0.46	42	547
	1190	BRAZED	0.77	0.25	46	509

TABLE 3 (continued)

5	Alloy	Braze Temp °C	Result	Nom. Tape Thickness	Deposit Thickness	% Thickness Loss	Hardness (Parent Alloy = 383 VPN)	5
10	A/C	1075	DNB	—	—	—	—	10
		1100	DNB	—	—	—	—	
		1125	DNB	—	—	—	—	
		1150	BRAZED	0.86	0.56	35	647	
		1175	BRAZED	0.86	0.50	42	639	
		1190	BRAZED	0.86	0.43	50	621	
15	C/D	1075	DNB	—	—	—	—	15
		1100	DNB	—	—	—	—	
		1125	DNB	—	—	—	—	
		1150	DNB	—	—	—	—	
		1175	BRAZED	0.71	0.41	42	596	
		1190	BRAZED	0.69	0.43	39	563	
20								20

On perusal of Table 3, several points become very clear e.g.

- 25 (a) Alloy C brazes over a much wider range of temperatures, than the remaining alloys.  
 (b) Alloy C suffers only marginally more than alloys A/C and C/D with regard to deposit thickness loss.  
 (c) All the alloys exhibit higher hardness values, at their respective lower brazing temperatures.  
 (d) Alloy C exhibits significant improvement in hardness value, even over its nearest competitor i.e. alloy A/C.  
 30 (e) Alloy C, when brazed to a nickel based parent alloy, at a temperature of 1100°C, for fifteen minutes, provides a surface, the hardness of which is substantially 95% harder than that of the parent alloy.  
 35 Tables 4 and 5 respectively show the composition of hard facing alloys B and C, after heating to effect brazing and compare these compositions with nominal. The tables also repeat the hardness values after brazing at given temperatures.

TABLE 4

40	Alloy	Brazing Temp °C	Co	Cr	W	Composition %		C	B	Hardness VPN	40
45	B	1190	41.6	17.8	9.0	2.5	21.7	—	—	446	45
		1150	45.9	20.3	8.9	2.6	12.7	—	—	513	
		Nominal	52.0	19.0	9.0	2.5	13.0	1.0	1.5		

50 Time at temperature 15 minutes  
 Carbon and Boron not capable of detection by MPA

TABLE 5

55	Alloy	Brazing Temp °C	Co	Cr	W	Composition %		C	B	Hardness VPN	55
60	C	1190	23.3	8.0	9.6	2.4	28.0	—	—	509	60
		1150	35.2	33.0	10.1	3.0	10.8	—	—	552	
		1100	42.3	30.7	10.6	4.6	2.8	—	—	746	
		Nominal	52.0	31.0	8.0	4.5	0	1.4	3.0		

65 Time at temperature 15 minutes  
 Carbon and Boron not detected by MPA

Reference to Table 4 clearly indicates that increasing the brazing temperature brings about diffusion of nickel, from the parent body into the hard facing layer B. In the present example, there is an increase of approximately 90% in the nickel content when brazing is effected at 1190°C. There is also a reduction of 13% in the hardness value.

- 5 Table 5 equally clearly shows that, on heating alloy C which initially contains no nickel, to the higher brazing temperature, there results a transfer of a quantity of nickel thereto, equal to 28% by weight of the total alloy C composition. Moreover, the dramatic increase in nickel content is matched by an equally dramatic drop in hardness value, and consequently reduced wear resistance. 5
- 10 Hard facing alloys A/C and C/D follow the trend set by alloy C in as much as they, being nickel free alloys, show a hardness increase of approximately 20% over alloy B, when brazed to the parent part, at temperatures which though high enough to effect brazing, are low enough to substantially inhibit transfer of nickel from the parent part to themselves. 10
- The invention thus teaches:-
- 15 (a) the use of a nickel free, cobalt based hard facing alloy, and 15  
(b) heating the parent part and the alloy to a temperature above, but quite near to, the liquidus of the alloy (Table 3) at least substantially prevent transfer of nickel from the parent part to the alloy, so as to:
- 20 (c) obtain a hard facing layer on the parent part, the hardness value of which layer is up to substantially 95% greater than the hardness of the parent part and up to 50% greater than was achievable with the cobalt based, hard facing alloys known heretofore. These increases in hardness bring about a significant improvement in the wear resistance of the hard facing alloy. 20

#### CLAIMS

- 25 1. A nickel free, hard facing alloy, having the following constituents in the proportions stated, as a weight percentage: 25

Co	50-60%	
30 Cr	5-35%	30
W	0-10%	
C	0-25%	
Si	0-10% where if Si = 0 some B is present,	
B	0-3.5% where if B = 0 some Si is present	
35		35
Remainder	impurities	

2. A nickel free, hard facing alloy having constituents as claimed in claim 1 wherein the proportions of those constituents by weight are: 40

Co	52%	
Cr	31%	
W	8%	
45 C	1.4%	45
Si	4.5%	
B	2.9%	

#### Remainder impurities

- 50 3. A nickel free, hard facing alloy as claimed in claim 1 wherein the alloy is reduced to a powder. 50

4. A nickel free, hard facing alloy as claimed in claim 3 wherein the mesh size of the powder is at least 45 microns and at most 105 microns.

- 55 5. A nickel free, hard facing alloy as claimed in claim 3 wherein the alloy is in the form of a flexible tape, being held in that form by a polymeric binder, the solvent content of which has been evaporated off. 55

6. A nickel free, hard facing alloy as claimed in claim 5 affixed to a surface of a nickel base alloy member, by laying said tape on said surface, then heating the resulting assembly in vacuum, at a temperature which is 10°C to 25°C above the liquidus of the hard facing alloy, for fifteen minutes. 60

7. A nickel free, hard facing alloy as claimed in claim 6 wherein the member with the tape applied thereto has been heated at substantially 500°C for thirty minutes before the temperature was raised to 10°C to 25°C above the liquidus of the hard facing alloy.